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Publication date:
2018

Document Version
Version created as part of publication process; publisher's layout; not normally made publicly available

Analysis of statistical properties of thirteen years of radar data

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Abstract

This study examines characteristics of high-resolution radar data (5-minute temporal resolution, 1x1 km spatial resolution) from the Deutsche Wetterdienst over an area of 1824 km2 covering the catchment of the river Wupper, North Rhine-Westphalia, Germany. The elevation varies from 31 meters to 483 meters above sea level and the mean annual precipitation in the area ranges from 770 mm to 1352 mm, due to strong orographic effects. Thirteen years of data, from November 1, 2000 to 1 November 2013, is used for the analysis.

This study aims to quantify and describe spatial rainfall as a function of temporal and spatial dynamics, rainfall types and seasonal variation. Descriptive statistical methods are applied to analyse selected physically based variables and their internal correlation.

Extreme events were sampled by a Peak Over Threshold method using several sampling strategies including different degrees of spatial coverage. All strategies select an average of three events per year.

A simple identification- and tracking algorithm for rain cells based on intensity threshold and fitting of ellipsoids, is developed for the study. Both hourly and daily extremes were analyzed with respect to a set of 16 descriptive variables (see Table 1).

Tab 1: Descriptive physically relevant variables used for the analysis of spatial rainfall. From Thomassen et al. (2018)

Variable	Short name	Unit	Description
Duration	Duration	Hours	From start to end with an extension of 2 hours in each end to consider the event in the entire case area.
Intensity	Max 10min	mm min^{-1}	Maximum average intensity for 10 minutes.
	Ratio 10min	-	Ratio between max 10 minute and mean 10-minute intensity.
	Max 1h	mm min^{-1}	Maximum average intensity for 1 hour.
	Max 24h	mm min^{-1}	Maximum average intensity for 24 hours.
Wet Area	Mean wet A	-	Average ratio of cells with precipitation (wet cells) from each time step of the event.
Depth	Min depth	mm	Value of the grid cell with the lowest depth in the case area.
	Max depth	mm	Value of the grid cell with the highest depth in the case area.
	Mean depth	mm	Average depth considering all cells in the case area.
	Ratio depth	-	Ratio between max depth and mean depth.
Rain cell properties	Cell num	-	Number of tracked rain cell in the rain event.
	Cell life	min	Average lifetime of the rain cells in the event.
Movement	Mean vel	m s^{-1}	Mean rain cell velocity
	Sd vel	m s^{-1}	Standard deviation of velocity.
	Mean dir	Degrees	Mean moving direction of rain cells, compass degrees.
	Sd dir	Degrees	Standard deviation of direction.

The spatio-temporal properties of the extreme events are explored by means of principal component analysis (PCA), cluster analysis, and linear models for these 16 variables.

The PCA indicated between 5 and 9 dimensions in the extreme event characteristic data. The cluster analyses identified four distinct rainfall types: extreme convective, convective, convective events in front systems and front system events (see Figure 1).

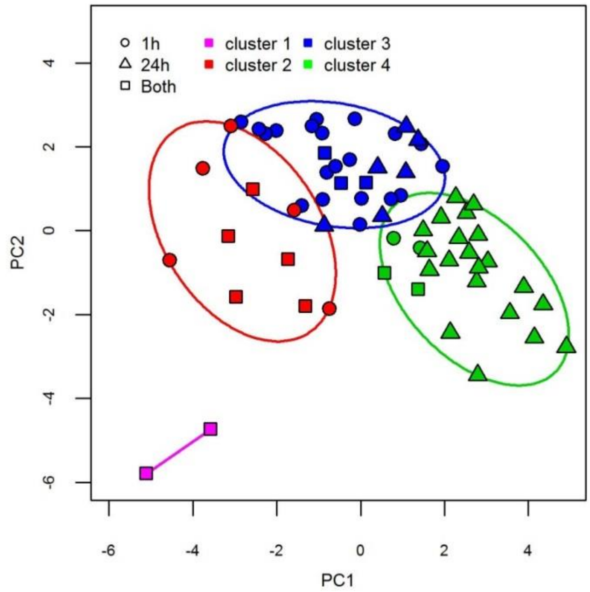

Fig 1: Statistical clustering of extreme events. Cluster 1: Extreme convective, cluster 2: Convective, cluster 3: Convective events within frontal systems, and cluster 4: Frontal system events. Modified from Thomassen et al. (2018).

The stepwise regression for each variable identified independent variables that correspond well with the correlation structure identified in the clusters. The results of this study conduct the preliminary steps prior to setting up a weather generator with similar properties as high-resolution radar rainfall data. The results point out which variables in such a weather generator should be considered independent and which could be co-varied. The study should be considered as a first step into the direction of good practises to find and analyse single storm events in radar rainfall data sets.

The full study is under revision for Hydrology and Earth System Sciences as Thomassen et al. (2018): doi: 10.5194/hess-2018-184.

References

Thomassen, E. D., Sørup, H. J. D., Scheibel, M., Einfalt, T., & Arnbjerg-Nielsen, K. (2018). Explorative Analysis of Long Time Series of Very High Resolution Spatial Rainfall. *Hydrology and Earth System Sciences Discussions*, 1–28. https://doi.org/10.5194/hess-2018-184